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Teaching an Old Profession New Tricks: An Analysis on the Effects of the Flipped Classroom Model on Student Performance

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CLAREMONT McKENNA COLLEGE

Teaching an Old Profession New Tricks: An Analysis on the Effects of the Flipped Classroom Model on Student Performance

SUBMITTED TO

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AND

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BY

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for

SENIOR THESIS

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Abstract

When traditional lecture methods prove ineffective, some professors turn to alternative teaching styles. In particular, a flipped or inverted classroom, where students watch conceptual videos before coming to class and use class time for application and fine tuning of these concepts has become popular in recent years. However, little consensus exists on the efficacy of these strategies. The purpose of this study is to determine whether a flipped classroom structure implemented in a medical school course successfully improved student performance. To do so, I analyzed exam data from the University of Nebraska Medical Center before and after implementation of the alternate method in a course, and compared to another class taken in the same semester that did not undergo any change in teaching style.

In addition, I investigated differences among particular student academic and demographic groups that may benefit from learning in an inverted classroom environment. My findings suggest that the flipped classroom strategy is advantageous to student learning and can significantly increase the performance of particular divisions of students such as those with lower-than-average MCAT scores and students who performed highly in their first year of medical school.

I. Introduction

In all levels of schooling, the information taught to students is regularly researched, revised, and updated to reflect the most accurate and up-to-date knowledge available. In Chemistry, atomic theories are constantly tested then altered to align with new data. Mathematical application is only expanding, along with useful computations introduced in the classroom. Even language adapts as new words and expressions come into play and older grammatical rules are retired with disuse. Despite the adaptability of and consensus on subjects taught, methods of conveying this information to students have remained stagnant for decades. It can be argued that, since the establishment of the United States, only two universal changes have been made to adapt to changing society, and even those are in response to the American Revolution and the market revolution, respectively (D. Parkerson and J. Parkerson 2001). Despite these cycles occurring about once a century, the rapidly changing demographic and technological landscape of the United States may be forcing a third revolution in this lifetime, where schooling moves towards educational variability in the forms of charter and magnet schools, standardized courses such as the Advanced Placement and International Baccalaureate programs, and adapted teaching styles for different learning and engagement methods.

Most recently, the role of technology in the classroom has been a point of contention. Just prior to the turn of the century, schools began budgeting more for technology than capital goods (Schrum 2011). Utilizing that technology, along with computers available in the home, has become a challenge for all academic institutions. Schools are attempting to find a balance among institution-provided resources, training, and class time, along with integrating these with student-owned technology and know-how. Many provide on-campus computer accessibility, with some loaning out school-owned laptops or, in a number of private institutions, even requiring the purchase of a personal computer for the duration of a student's enrollment.

Technology also has an impact inside the classroom. Many teachers now lecture off of Microsoft PowerPoint or Prezi presentations, project image and video examples to their students, communicate via email, and even assign work to be completed and graded online. Given available hardware and the capabilities of software, the possibilities for technology in the classroom are numerous. The question now is, out of so many options, what is the most effective? Objective truths may be known in the math and science classes taught, but how to best convey this information is still unclear. Insufficient research has been performed on ways to integrate traditional and technologically innovative teaching methods.

This paper will explore how one of these methods impacts student performance. I will be examining how past academic performance of second year medical students is related to their success in a new teaching environment and compare these results to those of a more traditionally taught class these students attended in the same semester. The second section of this paper reviews past research on the alternative methods in question. The third section provides information on the data. This is followed by a description of the analysis results in section four and ends with an interpretation of the results, along with conclusions that can be drawn from them.

II. Literature Review

In an effort to engage students as they learn in the classroom, many educators have sought out alternatives to traditional passive learning techniques. Instead, they have been pursuing active participation, with the hope that increased interaction will also increase student understanding of concepts and foster a better relationship with the education system. Some popular active learning techniques include peer instruction, mastery learning, and an inverted classroom method.

In peer instruction, students are asked to respond to questions on readings or concept tests they encounter at the beginning of class. They are given time to form their own opinions on topics before dispersing into peer groups where students discuss their ideas and attempt to come up with a consensus to the question asked (Mazur Group). The instructor then gauges the relevance of student responses and either asks additional questions on the concept for groups to consider or moves to another section.

Mastery learning is student-paced learning. Instead of allowing all students to progress to the next concept or class regardless of their level of achievement, tests are used to assess comprehension at an individual level. Students are required to demonstrate true understanding of material before they continue to a new topic, even if it means testing multiple times on the same subjects (Coursera Blog 2013). This type of learning is also more student-based; students are provided with material presented in multiple forms so they can utilize those that help them the most at a speed appropriate for them.

This paper aims to explore the success of the flipped classroom alternative to lecture style teaching. A flipped or inverted classroom is one in which basic lectures are reviewed by the students before class, freeing up class time for more application and active learning activities that the lecture style accounts for with homework (Center for Teaching and Learning). The rationale is that both sides of the flip are more beneficial for students. In a classroom lecture, there is not time to walk every student through issues of comprehension, nor do all students ask for direction when they are in need of help. Providing short video lectures before class allows pupils the opportunity to go through material at their own pace, rewind, and rewatch problem sections. In theory, this gives them a better understanding of course content than being lectured to at the professor's pace.

Class time, then, is structured to help students take advantage of the wealth of information that is their teacher. Generally some time is spent checking for student understanding, which allows teachers to gauge comprehension and adapt any in-class lecture to material that needs further explanation, while the majority of the period is spent solving problems that apply the video-lecture concepts. The instructor is then on-hand to help students work through these problems, correct misunderstandings, and answer questions on an individual basis (Kachka 2012).

Though some subjects, such as Literature classes, and some teaching styles like the case study approach in law school that adopted the inverted classroom method long ago, making it the current norm, there is not consensus on its success. Many supporters cite evidence based on observation, rather than the experimental method. These case studies boast outstanding improvements in pass rates and average scores, but fail to provide evidence that it is the teaching method, rather than other variables, such as an increase in funding or cohort differences, that have influenced outcomes. Some also fail to provide data from multiple repetitions of the inverted classroom style or omit information from previous years.

Despite the promise of inverted classrooms suggested by nonscientific data, with 67 percent reporting improved test scores and 80 percent claiming improved student attitudes (Goodwin and Miller 2013), actual scientific research had not been performed to quantify the effect of inverted classrooms until 2012. That year, four professors at Harvey Mudd College began a three-year study backed by the National Science Foundation to study impacts of the flipped classroom on student performance. They structured the experiment to explore effects such as student attitudes towards learning, their ability to apply video-lecture concepts, and exam scores(Atteberry 2013). Though the data is admittedly preliminary, so far results have not been promising, with professors reporting no statistical significance that an inverted classroom improves student learning.

This analysis aims to add to current research on the success of students who participate in the flipped classroom teaching style. The study attempts to control for other variables of potential influence that have not normally been considered in studies on flipped classroom methods. This approach will help parse the influence of said teaching style from other variables, and quantify their effects on student scores.

III. Background

The cardiology section of the University of Nebraska Medical Center's second year medical degree curriculum has historically been a problem for the university. Student evaluations on this section of the course have consistently been lower than average. In addition, professors and other staff members were concerned that students were unable to answer cardiology questions that, technically, they should have had all the resources to satisfy. In comprehensive exams, questions with too low a success rate are omitted from score calculations, many regularly from cardiology.

During the 2012-2013 school year, Professor S.[1] assumed responsibility for leading the cardiology unit. Following the structure of previous years, Dr. S. utilized the traditional lecture format. This entailed no class participation, voluntary class attendance, and lectures were made available to students online immediately following the live class. In addition to lectures, all students had access to the course syllabus, including suggested readings, and instructor-provided notes. Because students all had access to the same resources, whether they attended class or not, little advantage was seen to attending lecture. At the end of the semester, evaluations were lower than Dr. S. deemed acceptable- 2.6 on a four-point scale. As a result, he sought out alternative methods to relay cardiology course material to students.

After some preliminary research, Dr. S. determined the flipped classroom method to be best suited for teaching the same material while getting information

[1] Name withheld to protect privacy

across more effectively. With this in mind, he structured the next year's course to this technique. For the 2013-2014 cardiology course, Dr. S. created videos ranging from twelve to thirty minutes long for students to watch prior to lecture. The videos provided fundamentals for the material to be discussed. Class time was then dedicated to a more in-depth analysis of the concepts presented in the videos, application questions to stimulate student-professor interaction, and real-time polling questions facilitated by Dr. S. The real-time polling questions served two functions: one, to give students more exposure to application questions relevant to material in the cardiology section, and two, to evaluate student understanding the assigned videos in order to appropriately guide lecture based on student needs. Those who chose to participate in real-time polling, whether on- or off-site received feedback on the questions they answered within three business days.

Student response has been mostly positive. There was consistent participation in in-class polls; evaluations increased to 4.4 on a five point scale (a 23 percentage point increase in student satisfaction), and exam questions omitted due to low success rates have declined for cardiology.

The Cardiac Cycle and Valvular Heart Disease (CCVHD) and Electrocardiogram (EKG) are topics covered in the first semester and led by different professors. Test score data related to these topics were collected from the cumulative exams given to second year medical students during their first semesters of the 2012-2013 and 2013-2014 academic years. CCVHD and EKG scores were calculated from an individual's success in answering the questions correctly out of the number of questions on the exam related to the respective subject matter. To limit variability in exam difficulty over time and instructors, the majority of questions are chosen from a highly categorized test bank for consistent ratios of ease to difficulty and concepts tested, in addition to writing and introducing a specific percentage of new items each year. All scores and demographic data were provided by the University of Nebraska Medical Center.

IV. Data

Data for this research came from second year students at the University of Nebraska Medical Center during the 2012-2013 and 2013-2014 academic years. 2012-2013 represents data on 254 students under only lecture style teaching methods. 2013-2014 represents data on 248 students who experienced a flipped classroom teaching style for a single course. The course content from which exam scores were taken, along with the instructors teaching each section remained constant throughout.

Dependent variable

The measure for student performance is success on exams, represented by *Testscore*. Exam questions were categorized based on course section, with EKG and CCVHD as the sections of interest. Percentages were then calculated for individuals based on the number of correctly completed questions for a given course divided by the total number of questions on the content.

Treatment variable

To control for differences in instructors and course content, *Test* was introduced as a binary variable with 1 representing data related to EKG scores and 0 related to CCVHD. In order to distinguish between years exams were taken, the binary variable *dumsemest* was introduced. This variable expresses student scores from the 2013-2014 academic year as a 1, and from the 2012-2013 academic year as 0. Finally, to account for test scores earned under flipped classroom methods, *Treatment* is used where a value of 1 indicates the student learned material for the course under a flipped method and 0 expresses no deviation from the traditional lecture style.

Control variables

The students of any medical school class share many qualities. They must have a high enough work ethic and cognitive ability to have successfully graduated undergraduate school and been accepted to medical school, along with having a certain degree of physical and interpersonal ability. There are many other areas where they differ, however.

Some factors that may contribute to variation among students that are examined here include gender, undergraduate testing measures, and first year medical school testing measures. *gender* is a binary variable with 1 indicating a student who identifies as female and 0 a student who identifies as male.

undergradgpa represents a student's final undergraduate grade point average, as expressed on her transcript. It is important to note that this score has the potential to vary for students who are otherwise similar due to variation in the rigor of undergraduate institutions and courses pursued in undergraduate education.

A better measure of undergraduate performance may be Medical College Admissions Test (MCAT) scores. The MCAT is an exam prerequisite to students intending to apply to medical school that is standardized across the country and over time. In addition to the *mcat* variable, *quart* was generated as a representation of the quartile an individual's MCAT score fell into. Students who scored above or below the median MCAT score in this sample may respond differently to stimuli, so examining these are of interest.

Lastly, *m1comp* is a second year medical student's related first year comprehensive exam score. First year comprehensive success will most likely have predictive power for year two success. However, the score on this exam may also alter a student's behavior (eg. A student who performs well in the first year may feel comfortable studying less in year two, as he is confident in his abilities). Comprehensive test scores do not well reflect the variation of a single exam or topic. As such, it may be difficult to compare the comprehensive variable to course-specific percentages examined here.

Table 1. Summary statistics for variables of interest

Summary Statistics	Treatment Semester (1)	Control Semester (2)	Treatment Semester - Control Semester (1) - (2)
EKG Test Score	0.858	0.857	0.001
Number of Obs.	124	128	
CCVHD Test Score	0.758	0.575	0.183
Number of Obs.	124	128	
MCAT	30.659	29.89	0.769
Number of Obs.	246	254	
Undergraduate GPA	3.788	3.746	0.042
Number of Obs.	244	254	
First Year Comp Test Score	0.755	0.727	0.028
Number of Obs.	244	254	
Gender	0.427	0.405	0.022
Number of Obs.	248	252	

Initial assumptions

One concern when testing academic performance of cohorts is ability, an unobserved student characteristic. MCAT scores were the most complete and standardized measure available to me as a proxy for ability in medical school. When applying a t-test for MCAT scores between semesters, however, a strong statistical significance was discovered ($p = 0.007$***[2]). Further research indicates that, though there appears to be a relationship between MCAT scores and medical student performance, it does not have exceptional predictive power. A meta-analysis of twenty-three studies on the predictive power of the MCAT in relation to medical school performance and/or medical licensing examinations revealed that the MCAT and its subtests only has small to medium predictive validity in medical school (Donnon, Paolucci, and Violato 2007). This may be due to a difference in skills that the MCAT and medical school assess. For example, where the MCAT rewards test-takers with high levels of knowledge in specific areas, medical school focuses on testing practical skills and application of knowledge. The significant difference of MCAT scores between cohorts, then, is not necessarily an indication that the success of one cohort in medical school is inherently higher than another.

Next, I pursued another potential measurement for differences in ability. Since undergraduate performance does not seem to be a strong indicator, it follows that graduate performance, where the same skills are being tested, may be. The same semester that students were tested in the CCVHD section, they were also

[2] Statistical significance is notated as *, **, *** at the ten percent, five percent, and one percent levels, respectively

enrolled in an EKG course with a final skills evaluation. If there is a significant difference in EKG scores between the two years, when teaching and evaluation were held relatively constant with the same professor, teaching style, and testing methods, it is more probable that the score difference is due to student ability. Performing a t-test on these exam results yields a p-statistic of 0.968, indicating no statistical significance. This means there does not seem to be a significant difference in medical school abilities between cohorts of the two years. As a result, large differences in test scores over time seems better explained by the independent variable; that is, the application of flipped classroom methods over one of the semesters.

Test scores are not normalized among all variables; as such, one must keep these distinctions in mind when comparing statistics. As a result EKG appears to have fundamentally higher test scores. Indeed, regressing the EKG class on test scores reveals a coefficient of 0.191***. Variation is to be expected here due to unique course content and instructors. Since the topics and professors remain the same over the years, however, scores should remain consistent for the same class over time.

V. Econometric Methods and Results

The basic regression model used here is a multiple variable regression controlling for demographic variation. The model is as follows:

$$\text{Testscore}_i = \beta_0 + \beta_1\text{MCAT}_i + \beta_2\text{undergradGPA}_i + \beta_3\text{gender}_i + \beta_4\text{m1comp}_i + \beta_5\text{dumsemest}_i + \varepsilon_i$$

The impact of measurements such as MCAT scores, undergraduate GPA, and gender are not consistent between classes. Data collected in both years for the EKG course show undergraduate GPA and a first year comprehensive exam to have significant predictive power on EKG exam scores, whereas the CCVHD section displays higher levels of GPA and first year predictive power.

Initial statistics also show close to a ten percentage point difference in average scores between 2012 and 2013. Test scores appear to improve significantly by 7.8 percentage points*** for students lucky enough to have tested in 2013, when the flipped classroom was implemented. The influence of the flipped classroom continues to hold true with more detailed analysis. When looking at the effect of the year on scores in each class, there is no significance for the EKG exam percentage ($p = 0.638$), whereas the CCVHD scores increase by 0.165***. Under the belief that student ability has not altered from one year to the next, and with the knowledge that the courses and professors have not changed, there is good reason to believe that the implementation of a flipped classroom method has affected student scores.

Table 2. Multi-variable regression of CCVHD class[3]

CCVHD	Coef	Std. Err.	Obs
mcat	0.004	0.004	246
undergradgpa**	0.112 (0.036)	0.053	
gender	0.016	0.023	
m1comp***	0.324 (0.004)	0.11	
Treatment***	0.165 (0.000)	0.023	

Control variables seem to have different effects on the scores of students under different teaching methods. The significance of one's undergraduate GPA and first year comprehensive tests both increase for CCVHD exam scores (Table 2), in comparison to EKG results (Table 3). In addition, the flipped treatment has a highly significant (p = 0.000***) impact on the test scores of the students in the former class. So far, the inverted classroom has held consistent with the theory that it is beneficial to student performance.

Table 3. Multi-variable regression of EKG class[4]

EKG	Coef	Std. Err.	Obs
mcat	0.002	0.003	246
undergradgpa*	0.083 (0.058)	0.043	
gender	-0.024	0.019	
m1comp**	0.216 (0.017)	0.090	
dumsemest	-0.009	0.019	

[3] *dumsemest* omitted due to collinearity
[4] *Treatment* omitted due to collinearity

To delve further into how students of different academic factions are affected by alternate teaching styles, I analyzed the impacts of a flipped classroom on those who scored above and below the median MCAT scores for this sample (Table 4). MCAT scores were chosen due to their consistency in material and difficulty over time and geography, unlike undergraduate GPAs, which may vary among schools and contributing classes, and its completeness in this data set. In the altered classroom, only MCAT (p = 0.081*) appears to be a significant contributor to exam scores for students who scored below the median (Table 4). Those who scored above the median MCAT express high predictive ability for first year comprehensive exam scores (p = 0.004***) in addition to MCAT scores, which have a significantly *negative* relationship (p = 0.077*) to exam scores. It should no longer come as a surprise that the test scores of students who score both above and below the median are greatly impacted by the presence of the flipped classroom treatment (p = 0.000*** in both cases).

Table 4. Multi-variable regression of treatment group by MCAT score[5]

Above median	Coef	Std. Err.	Obs
mcat*	-0.016	0.009	108
	(0.077)		
undergradgpa	0.124	0.091	
gender	(0.002)	0.036	
m1comp***	0.546	0.183	
	(0.004)		
Treatment***	0.133	0.035	
	(0.000)		

Below median	Coef	Std. Err.	Obs
mcat*	0.015	0.008	138
	(0.081)		
undergradgpa	0.069	0.066	
gender	0.033	0.030	
m1comp	0.196	0.137	
Treatment***	0.181	0.031	
	(0.000)		

[5] *dumsemest* omitted due to collinearity

VI. Discussion

The significant increase in student test scores from 2012 to 2013, when the flipped classroom was implemented, implies that some stark change occurred. To the best of his ability, however, Dr. S. had controlled for major differences in content and examinations. I tested for demographic discrepancies and found the two essentially the same, making the 7.8*** advantage for the more recent year a more promising result.

In addition, testing the effect of different years on CCVHD and EKG scores separately continued to show a significant difference, but only for the CCVHD exam questions. This strengthens the evidence that it was a variable change in some aspect of CCVHD that was not present in the EKG course responsible for the significant score difference. The only large identifiable variation is the inverted classroom that was imposed, for CCVHD only, in 2013. This paper will thus continue under the assumption that it is the change in teaching style that is responsible for the change.

Having identified 2013 as a year of interest and CCVHD as a class of interest, I pursued further analysis in this segment. Given the lack of scientific research on flipped classrooms, it has been difficult for teachers to determine what traits contribute to higher success and for whom this method is most conducive. Classroom traits are beyond the scope of this study. Though we can say it seems to have been effective in a large, higher education class based in scientific knowledge, which, if any, of these factors contributes to better student performance under a flipped classroom remains unknown. These data did provide a glimpse into student traits that may predict the type of person who would benefit from a flipped classroom.

For CCVHD questions, students who perform well their first year appear to continue to do so the following year, yet this effect does not appear to be as strong for the EKG class. The influence of one's undergraduate GPA, as well, seems to fade from CCVHD to EKG. This could be due to inherent differences in the courses, but cannot be determined by this study. The dilution of significant student traits from one course to another could be of note in the future, however.

When the treatment group is considered in terms of MCAT scores, there is a highly significant relationship between year one comprehensive exam scores and year two scores for those with above median MCAT scores ($p = 0.000^{***}$), but this effect disappears for those whose MCAT scores were below the median. It is somewhat unexpected that first year success is only a predictor of second year performance for those with high MCAT scores. Despite the claims of prior research, this may mean that the MCAT actually can act as an indicator of medical school success.

Though the application of a flipped classroom had a significant effect for both high and low MCAT scorers, it exhibits a greater coefficient on those who scored below the median. These students seem to have had a smaller knowledge base coming into medical school than those who scored above the median. It is possible, then, that the inverted classroom is helping them build up that knowledge base in addition to adding the new material taught in the course. If this is true, a flipped classroom would effectively aid students who enter a class with lower scores and understanding catch up to their higher performing peers without limiting the class in any way. Another hypothesis is that the flipped classroom can assist students who prefer different learning styles, where one group is disadvantaged by traditional lecture style courses. For example, students who respond well to lecture may have exhibited higher scores in their first year exam, where those who benefit from more hands-on learning struggled. A flipped classroom provides both lecture in the video portion of class preparation, and interactive learning during scheduled class time. In either case, this would be very valuable to the academic world. Helping low performing students is always beneficial, but can be difficult in a group setting without interrupting a syllabus or delaying students who already perform at a high level. If a flipped classroom helps students of both high and low success without separating the two groups, it could aid in the adoption of alternative teaching methods. And if those methods are as influential as they appear, this could alter education into the future.

Restrictions and recommendations for future research

More research is necessary to know for certain why some students perform better in an inverted classroom. In particular, in the future, the impact of gender and preferred learning styles on performance in a flipped classroom may yield interesting results. If these are pursued, the possibility for an interaction between learning style and gender should also be considered.

In addition, repetition is necessary to confidently claim success in medical schools. More data on student performance in the CCVHD section both before and after implementation of the flipped classroom will provide additional certainty as to what is influencing student outcomes. EKG data for the same years will help strengthen the control, as would scores from other lecture-based courses.

Finally, 2013 being the first year change was implemented, the transition was not perfectly smooth and Dr. S. found many areas for improvement. With the change in teaching style, there was change in expectations for students in terms of pre-lecture participation. Communication of these expectations could have been clearer to prevent student confusion about the course. Uncertainty in the prerequisites for class may have resulted in lower participation rates for the conceptual videos. Ensuring that expectations are outlined for both professor and students prior to the first day of class could improve participation and success rates of the flipped classroom.

Fortunately, both of these concerns are being accounted for by Dr. S. in his forthcoming years teaching the CCVHD course. With improved implementation and a method of appraising the success of the teaching method as outlined in this paper, future data can yield results with more conviction. For now, there appears to be a relationship between the flipped classroom and improved student performance. This correlation definitely warrants more research, particularly in determining how a flipped classroom impacts subgroups, which I strongly recommend pursuing in the future.

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Appendix

Summary statistics

Variable	Obs	Mean	Std. Dev.
EKG	252	0.857	0.15
CCVHD	252	0.665	0.207

Variable	Obs	Mean	Std. Dev.
2011-2012	254	0.717	0.236
2012-2013	248	0.806	0.154

Two sample t-tests with equal variances

Difference in mean MCAT scores between years of study

Group	Obs	Mean	Std. Err.
2011-2012	254	29.88976	0.1994715
2012-2013	246	30.65854	0.2010144

diff= mean(1)-mean(2)	t = -2.7143
Ho: diff=0	df = 498
Ha: diff != 0	Pr(|T| > |t|) = 0.0069

Difference in mean EKG scores between years of study

Group	Obs	Mean	Std. Err.
2011-2012	127	0.8582677	0.0134068
2012-2013	124	0.8575	0.0133713

diff= mean(1)-mean(2)	t = 0.0405
Ho: diff=0	df = 249
Ha: diff != 0	Pr(|T| > |t|) = 0.9677

Regressions

Control variables and *Test*

Variable	Coef	Std. Err.	P > |t|	Obs	R squared
Test***	0.191	0.015	0.000	492	0.314
mcat	0.003	0.003	0.237		
undergradgpa***	0.097	0.035	0.006		
gender	-0.004	0.016	0.802		
m1comp***	0.270	0.074	0.000		
dumsemest***	0.078	0.016	0.000		

Control variables for EKG *Testscore*

EKG	Coef	Std. Err.	P > |t|	Obs	R squared
mcat	0.002	0.003	0.613	246	0.056
undergradgpa*	0.083	0.043	0.058		
gender	-0.024	0.019	0.207		
m1comp**	0.216	0.090	0.017		
dumsemest	-0.090	0.019	0.638		

Control variables for CCVHD *Testscore*

CCVHD	Coef	Std. Err.	P > |t|	Obs	R squared
mcat	0.004	0.004	0.244	246	0.259
undergradgpa**	0.112	0.053	0.036		
gender	0.016	0.023	0.487		
m1comp***	0.324	0.110	0.004		
dumsemest	0.165	0.023	0.329		

Control variables and *dumsemest*

Variable	Coef	Std. Err.	P > |t|	Obs	R squared
mcat	0.003	0.003	0.303	492	0.094
undergradgpa**	0.097	0.041	0.017		
gender	-0.004	0.018	0.827		
m1comp***	0.270	0.085	0.002		
dumsemest***	0.078	0.018	0.000		